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Contestable Licensing*

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Abstract

We analyze a model of repeated franchise bidding for natural monopoly with contestable licensing – a franchisee holds an (exclusive) license to operate a franchise until another firm offers to pay more for it. In a world where quality is observable but not verifiable, the simple regulatory scheme we describe combines market-like incentives with regulatory oversight to generate efficient outcomes.

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1. Introduction

We analyze a model of (repeated) franchise bidding for natural monopoly that relies on contestable licensing – the right to operate the franchise belongs to the party who owns the appropriate license as long as the license is not successfully contested through a process of competitive bidding – and demonstrate the usefulness of contestable licensing in inducing high quality performance from incumbent franchisees. In a world where quality is observable but not verifiable, the simple regulatory scheme we describe combines market-like incentives with regulatory oversight to generate efficient outcomes.

Our analysis builds on the "Chicago approach" to regulating a natural monopoly (Demsetz (1968), Stigler (1968), and Posner (1972)).[1] We consider a natural monopoly franchise such as cable television, garbage collection, electric power generation, or railroad operation. Every period, the incumbent monopolist (franchisee) may either provide high quality service which yields a "normal" rent, or low quality service, which results in a correspondingly higher per-period rent for the monopolist. We assume that consumers benefit from high quality service, and moreover, providing high quality service is also efficient. The quality of service is observable by the relevant regulatory agency, but is not verifiable in court. Because of this inherent non-verifiability, the political economy environment in which the regulator operates makes it difficult for the regulator to credibly commit to transfer the franchise to another firm upon observation of low quality service.

For example, in the case of cable television franchising, Viscusi et. al. (1995) write that the Cable Communications Act of 1984 "made it more difficult for a local government to fail to renew a cable company's franchise. To do so, the cable company must have violated the franchise agreement and, even in that case, the company had to be given adequate opportunity to rectify the situation" (p. 444). Indeed, Zupan (1989) reports that out of 3516 cable TV refranchising decisions during the 80s, only seven resulted in the local government removing the current franchise owner.

We do not attempt to model the reason for why it is the case that, in many practical situations, regulators find it difficult to commit to penalize low quality service. The existing literature (McCubbins (1985), Calvert, McCubbins, and Weingast (1989), and Laffont and

[1] However, the idea of franchise bidding dates back at least to Mill (1848) and Chadwick (1859) (Schmalensee, 1979).

Tirole (1994, ch. 15)) suggests that lawmakers may want to restrict regulators' discretion in order to align it better with lawmakers' objectives, and to reduce the extent of rent seeking behavior together with its implied potential for regulatory capture. In light of this, the franchise bidding scheme we describe facilitates such commitment by minimally increasing the discretionary power of the regulator in a way that keeps the potential for abuse by opportunistic regulators under check.[2]

At this stage, it is useful to abstract away from considerations of pricing and the ability of the regulator to observe other variables besides quality (e.g., cost and sales). As will become clearer below, such considerations are anyway orthogonal to the main part of our discussion.

We consider a model where every period a rival firm may contest the right of the incumbent franchisee to operate the franchise by making a bid for the license to operate the franchise. The incumbent franchisee may submit a counter-bid, and whoever made the highest bid wins the right to operate the franchise until the next challenger appears, upon which the whole process is repeated. We describe conditions under which a franchisee who provides low quality service is quickly replaced by another in equilibrium. On the other hand, a franchisee who provides high quality service, can expect to hold the license for a long period of time. Thus, when the incumbent franchisee considers the present value of providing high versus low quality service, the former yields a higher discounted payoff. As a result, franchisees who intend to provide high quality service are also willing to pay more for the license, and they always win the bidding contest against opponents who have the same technological capability but intend to provide low quality service. Furthermore, under some additional plausible assumptions that are described below, this is the *only* pattern of behavior that is consistent with subgame perfect equilibrium.

The regulator's role in all of this is important but minimal: First, it must design the franchise contract in a way that allows a franchisee who provides high quality service for a long period of time to earn higher (discounted) profits than a franchisee who provides low quality service for a short period of time. Second, if a rival firm is willing to pay more for the license than the incumbent franchisee, then the regulator awards it with the right to operate the franchise; if the incumbent is willing to pay more than the rival firm, then it retains the license. Only when the rival firm and the incumbent franchisee are willing to pay equal amounts for the license, is the regulator called to exercise judgement. In this case, the

[2] For additional discussion of this point, see Section 4.1 below.

regulator should award the license to the incumbent franchisee if it provided high quality service in the past, and to the rival firm if the incumbent provided low quality service in the past.

Our analysis gives rise to a number of interesting conclusions. First, the formal separation in the model between the issue of the quality of service on the one hand, and the price and cost of operation on the other hand, allows us to describe a regulatory scheme that permits the combination of assuring high quality service together with the provision of "high-powered" incentives.[3] This is due to the fact that, as we show below, contestable licensing ensures high quality service, and it allows the regulator, in addition, to design a *separate* incentive scheme that is highly responsive to the franchisee's cost savings and sales. In contrast, much of the literature has emphasized that when quality is not contractible, high quality performance necessitates the provision of low powered incentives.[4]

Second, repeated competitive bidding allows the regulator to encourage entry of more efficient firms, and puts pressure on the incumbent franchisee to innovate and invest in improving its technological capability.[5,6]

Third, unlike Demsetz (1968) and Stigler (1968) that call for awarding the franchise to the firm that offers to supply the service on the best terms, or Posner (1972) that recommends that firms compete for the license through bids that combine terms of service and lump sum payments, we show that the incentives to provide high quality service are better preserved when the franchise is awarded to the firm that is offering to pay the largest lump sum for it. Previous authors emphasized that once a monopolist obtains exclusive right to operate a franchise through competition, it has an incentive to provide low quality service unless the competition was specifically on the terms of the franchise contract. We highlight a different concern. Namely, especially in those situations where important aspects of the quality of

[3] Incentives are "high powered" if the regulated firm is allowed to capture a large fraction of its cost savings. They are "low powered" if the opposite is true.

[4] Laffont and Tirole (1994) for example write "When incentives for noncontractible quality are provided by reputational concerns, low-powered incentives are needed to encourage its provision." (p. 664) See also Laffont and Tirole (1991) and the references therein.

[5] On this account, we differ from Stigler (1968) and Demsetz (1968) who considered competition for once-and-for-all contracts or (incomplete) long term contracts, respectively.

[6] Previous authors have also emphasized the flexibility afforded by repeated short-term contracting which allows to adjust for new, non-contracted-for, circumstances (see, e.g., Williamson (1985, p. 339)). We do not address this important advantage of repeated contracting formally in our model.

service are non-verifiable, competition over the terms of the franchise service could encourage operators who promise excellent terms of service, but provide very low quality service once they obtain the license.

Fourth, following the Chicago approach and unlike Laffont and Tirole (1988), we show that the preservation of dynamic incentives is better served with the imposition of bidding parity between the incumbent franchisee and the rival firm.[7]

Fifth, as a consequence of the fact that, in equilibrium, an incumbent franchisee that provides high quality service can expect to remain the incumbent for a relatively long period of time, the "dynamic costs" associated with the fact that incumbent franchisees may underinvest in capital equipment for fear they will not be able to recoup their investment in case they are replaced, need not be large.[8]

Finally, because on the equilibrium path, the incumbent franchisee is never challenged, the transaction costs associated with running a series of bidding contests need not be large either.[9]

Williamson (1976) famously criticized the "Chicago approach" for what he claimed was its sanguine dismissal of the related issues of sunk costs, the incentives to invest, the transferability of investment, and asset specificity. We take up this criticism, and explain the way in which our approach deals with these issues in Section 4.3 below.

The analysis presented here relates to the previous theoretical literature on franchise bidding (Laffont and Tirole (1987), McAfee and McMillan (1987), and Riordan and Sappington (1987)).[10] This literature has mostly considered once-and-for-all bidding,[11] and focused on the "separation" between the competitive bidding stage and the regulation stage, obtaining the result that the winner of the franchise can be regulated as if the competition did not take place. Our focus is different. In contrast to this "mechanism design" inspired literature which studied franchise bidding under asymmetric information but with "complete contracting" ability, we consider a situation with complete information but incomplete contracting

[7] Laffont and Tirole (1988) considered a two-period model where distortion away from bidding parity in the second period improves efficiency by affecting the incumbent franchisee's incentives to invest in the first period.

[8] See Williamson (1976) and Laffont and Tirole (1988).

[9] See Williamson (1976).

[10] See also Laffont and Tirole (1994) and the references therein.

[11] However, as mentioned above in footnote 8, Laffont and Tirole (1988) considered the case of twice repeated bidding. Riordan and Sappington (1989) offer related analysis.

ability. In this environment, we show that allowing for repeated franchise bidding exerts a strong disciplinary pressure on the incumbent franchisee to provide high quality service and invest in improving its technology.

Another related work is that of Klein and Leffler (1981) who studied the issue of whether the market mechanism (repeat-purchase) can be counted on to ensure high quality performance in those circumstances where quality is not directly contractible.[12] The necessary and sufficient condition they identified, namely, that market prices are set high enough so that the discounted stream of rents to the firm with high quality performance is greater than the rents obtained from nonperformance, has a direct analog in our model (regulator rule 1 below). However, while this condition is necessary in our model as well, it is not sufficient.

Finally, the basic idea of "contestable licensing" shares at least some of its motivation with the idea of "contestable markets" as formulated in Baumol, Panzar, and Willig (1982), and the references therein. Both rely on the notion of contestability as the threat of competition rather than actual competition to discipline incumbent firms. However, there are several important differences between the two approaches. A perfectly contestable market is one where all producers have access to the same technology that does not involve sunk costs. Neither of these assumptions is required in our model. Perhaps more importantly, we are interested in a different question. While the contestability literature formulates conditions under which regulatory intervention (except for securing easy entry and exit) is unnecessary, and derives implications with respect to market structure, our goal is to utilize the idea of contestability for the purpose of designing a regulatory scheme that calls for much greater regulatory oversight.

The rest of the paper proceeds as follows. In the next section we present the model. In Section 3, we proceed to describe our assumptions about the regulator's and firms' strategic behavior. We describe the (unique) subgame perfect equilibrium and provide some (counter-) examples. In Section 4, we discuss the robustness of our results to the possibility of regulatory capture (4.1), to the introduction of uncertainty (4.2), and the issues of sunk costs, the transferability of investment, and asset specificity (4.3). Brief concluding comments are presented in Section 5. All proofs are relegated to the Appendix.

[12] See also Shapiro (1983).

2. The Model

Let J be a large set of risk-neutral firms that are all potentially capable of operating some natural monopoly franchise. We assume that the firms' per-period opportunity costs are identical and equal to zero. A firm's technological capability at a given point in time is summarized by a real number $a \in \{a_1, a_2, ...\}$, where $a_{k+1} > a_k$ for every $k \geq 1$. The higher is a, the more advanced is the firm's technology. We model technological progress in the following way: the set of technologies available at any period $t \geq 1$ is exogenously given by $\{a_1, ..., a_t\}$. We assume that in any period t, a firm with technological capability $a_k \in \{a_1, ..., a_t\}$ may invest an amount $c_t \geq 0$ to ensure that it will have a technological capability a_{k+1} in period $t+1$. A firm that does not invest in technological improvement retains its current technological capability.[13]

Every period, the incumbent franchisee chooses whether to provide high or low quality service. Recall that providing high quality service is assumed to be more efficient. The incumbent's choice of quality in period t is denoted by $q_t \in \{q_L, q_H\}$ where q_L denotes low and q_H denotes high quality service, respectively.[14] For example, a firm can provide low quality service by offering only few or inferior choices (in the case of cable TV), by not installing a sufficiently large capacity to handle emergency situations, by neglecting to provide proper maintenance (in the case of a toll road), etc. We assume that the incumbent franchisee's choice of quality is observable by the regulator but not verifiable in court.

The social welfare generated by the incumbent franchisee in period t (which we identify with the regulator's per-period objective function) is given by $w_t = w_t(a_t, q_t)$. We assume that for every $t \geq 1$, $w_t(\cdot, \cdot)$ is increasing in the incumbent franchisee's technological capability a_t (as this implies lower cost for the franchisee which can be translated into savings for the consumers) and in the quality of service. That is, other things being equal, a more technologically advanced incumbent franchisee and an incumbent franchisee that provides

[13] The deterministic nature of technological progress in our model is motivated by the fact that we view the investment in technological improvement as an attempt to keep up with current state-of-the-art technology, rather than as innovative path-breaking research. See also the discussion in Section 4.2 below.

[14] In many applications, quality is likely to be multi-dimensional. This does not affect our results as long as there exists a monotone function that maps quality into $\{q_L, q_H\}$. The fact that we only distinguish between high and low quality involves no loss of generality since the "efficient" quality (and higher qualities) can be mapped into q_H, and lower qualities into q_L.

high quality service generate a higher per-period social welfare. The function w_t should thus be interpreted as a "reduced form" of a more general social welfare function that depends, among other things, on consumers surplus, producer surplus, and productive efficiency. Our main concern is with high quality performance. Obviously, if the franchisee's technological capability is verifiable, the regulator can incorporate it into the franchise contract. As will become clearer below, our analysis also applies in the case where the franchisee's technological capability is not verifiable.

The payoff to the incumbent franchisee in period t depends on the terms of the license to operate the franchise in period t (which are determined by the regulator) and on the incumbent franchisee's choice of quality. It may include a transfer to or from the regulator that may depend on the franchisee's technological capability, the cost incurred by the franchisee,[15] the revenue collected by the franchisee, etc.[16] We denote the per-period profit to the incumbent franchisee in period t by $\pi_t(a_t, q_t)$ and assume that for every $t \geq 1$, the regulator sets the terms of the license such that $\pi_t(\cdot, \cdot)$ is increasing in the incumbent franchisee's technological capability. We also assume that $\pi_t(\cdot, \cdot)$ is decreasing in the quality of service. This is a consequence of the fact that quality is not verifiable. As much as it would like to, the regulator cannot reward the franchisee for providing high quality service. Thus, although demand may be increasing with the quality of service, the incumbent franchisee's additional revenues when providing high quality service are assumed to be lower than the additional costs.[17] To conclude, other things being equal, a more technologically advanced

[15] This cost does not include possibly large, but infrequently incurred, set-up costs. These are discussed seperately in Section 4.3 below.

[16] For example, consider a franchise to operate a toll bridge where demand is inelastic with respect to the quality of service. The regulator may control the incumbent franchisee's profit by specifying toll charges. Other things equal, an incumbent franchisee that provides lower quality service obtains higher per-period profit.

[17] Since the incumbent is a regulated monopolist who can only charge a price that is constrained by the regulator, this is not inconsistent with the assumption that high quality service is efficient. For example, suppose that average costs are constant and equal to marginal costs. If the regulator fixes the price at the marginal cost of providing high quality service, the incumbent franchisee's profit is zero if it provides high quality service, but positive if it provides low quality service. Similar examples can be given for the case where (corresponding to Regulator's Rule 1 below) the regulator allows the incumbent to make a positive profit when it provides high quality service. Because the incumbent has market power, in many cases it could have an incentive to provide low quality service at the regulated price in spite of the fact that high quality service is efficient.

incumbent franchisee and an incumbent franchisee that provides lower quality service obtain a higher per-period payoff.

We assume that the firms discount all future payoffs according to the commonly known (real) interest rate, $r > 0$.

We do not specify the terms of the franchise contract that are independent of the franchisee's choice of quality. However, we do assume that every such term can be enforced. While we abstract from such considerations in the paper, note that the regulator may adapt the terms of the franchise contract in every period to suit changing conditions. This formal separation allows us to obtain our conclusions about the possibility of providing "high-powered" incentives together with the assurance of high quality service.

The game proceeds as follows. In every period $t \geq 1$:

1. The incumbent franchisee decides whether or not to provide high quality service and whether to undertake a technology enhancing investment c_t.

2. At the end of the period, the payoff to the incumbent franchisee and social welfare to society are realized.

3. Next, a rival firm appears. We assume that the rival firm has a better technology than the incumbent's whenever such a better technology exists.[18] Otherwise, we assume that the rival firm has the same technological capability as the incumbent's. The rival firm may bid for the license to operate the franchise. We denote its bid by $b_t^R \geq 0$. We assume that preparing and submitting the bid requires the rival firm to incur a small cost, μb_t^R, which is proportional to its bid. Finally, the challenger's bid is constrained to be an integer multiple of some bid increment $m > 0$ that is assumed to be small relative to the advantage conferred by better technological capability, or $\pi_t(a_t, \cdot) - \pi_t(a_{t-1}, \cdot)$, for every $t \geq 1$.

4. The incumbent franchisee observes the challenger's bid and may respond by making a counter-bid $b_t^I \geq 0$ at a cost μb_t^I.[19] The counter-bid b_t^I is constrained to be an integer

[18] There is no need to specify how much better the rival firm's technology is. As Lemma 3 in the appendix shows, in equilibrium, more technologically advanced firms always defeat less technologically advanced firms.

[19] The assumption that the cost of bidding is proportional to the submitted bid is not necessary for our results to hold. It could be replaced, for example, by the assumption that submitting any positive bid requires bidders to incure a small fixed cost.

multiple of the bid increment m.

5. The regulator awards the franchise to the highest bidder, provided (exactly) one exists. The highest bidder pays the regulatory agency an amount equal to its bid. The regulator's action in case the bids are tied is specified below in the second regulator's rule.

It is understood that the right to operate the franchise belongs to the incumbent franchisee as long as the terms of the franchise contract are satisfied, and the regulator did not award the right to operate the franchise to another firm through competitive bidding as specified above.

The description of the game above corresponds to a situation where several different firms provide the same franchise service in close but different geographical locations. Every such firm is eager to expand its franchise service to additional areas, and so invests in improving its technological capability to maintain its competitiveness. Whenever the technological capability of the incumbent franchisee in any particular location falls below that of one of its competitors, the latter, who because of its technological advantage, expects to be able to pay more for the license to operate the franchise, challenges the incumbent franchisee in an attempt to obtain the franchise contract.

3. Equilibrium Analysis

In general, the franchisee is subject to two moral hazard problems. It is expected to provide high quality service and to invest in maintaining its technological capability. In the next three subsections, we first present the simplest case where technology is verifiable. We then show that our results apply when firms may differ in their technological capabilities that, in addition, may be observable but not verifiable. Finally, we address the case where the franchisee's technological capability is not observable by the regulator.

3.1. "Pure" Moral Hazard: The Case of Verifiable Technology

In this subsection, we assume that the firms' technological capability is verifiable, and the regulator, efficiently, requires all incumbent franchisees to invest in maintaining their technological capabilities or give up their license. We present two rules that, if followed by the

regulator, guarantee that providing high quality service is a subgame perfect equilibrium outcome of the game above. The equilibrium is such that a franchisee that provides low quality service, while earning a higher per period payoff, can only expect to remain the incumbent franchisee for one period. On the other hand, an incumbent franchisee that provides high quality service (and earns a lower per-period payoff), can expect to remain the incumbent franchisee forever. The first rule is:

Regulator's Rule 1. (RR1) *The regulator sets the terms of the franchise contract such that the payoff to the franchisee from providing low quality service for one period is lower than the discounted sum of benefits associated with providing high quality service forever while incurring the cost of maintaining high technological capability in every period. Or, for every* $t \geq 1$,

$$\sum_{\tau=1}^{\infty} \left(\frac{1}{1+r}\right)^{\tau} \left[\pi_{t+\tau}\left(a_{t+\tau}, q_H\right) - c_{t+\tau}\right] > \left(\frac{1}{1+r}\right) \pi_{t+1}\left(a_{t+1}, q_L\right). \qquad (*)$$

It is important to observe that the rule above can be easily followed. Suppose, for example, that the regulator sets exactly the same franchise contract every period, and that this contract generates per-period profits of $\overline{\pi}$ and $\underline{\pi} < \overline{\pi}$ to the franchisee if it provides low or high quality service, respectively. Suppose also that the cost of maintaining high technological capability is zero. In this case $(*)$ reduces to

$$\frac{1}{r} \cdot \underline{\pi} > \frac{1}{1+r} \cdot \overline{\pi},$$

which is satisfied whenever the interest rate r is low enough. In case the interest rate is not sufficiently low, the regulator can still ensure that $(*)$ is satisfied by increasing the per-period profit of the incumbent franchisee by some constant C.[20,21] Depending on the context, the regulator would have different instruments available for achieving this purpose. For example, when the regulator controls prices, this can be achieved by allowing the franchisee to charge higher prices. Of course, demand must be sufficiently inelastic so that the efficiency loss from

[20] Specifically, if

$$\sum_{\tau=1}^{\infty} \left(\frac{1}{1+r}\right)^{\tau} \left[\pi_{t+\tau}\left(a_{t+\tau}, q_H\right) - c_{t+\tau}\right] - \left(\frac{1}{1+r}\right) \pi_{t+1}\left(a_{t+1}, q_L\right) = -\delta < 0.$$

then C must be larger than $r(1+r)\delta$.

[21] Thus, as in Klein and Leffler (1981), it is necessary to let the incumbent franchisee capture a positive rent to ensure high quality performance.

pricing farther above marginal cost is smaller than the resulting gain from the provision of high quality service.[22] In any case, since regulation determines the incumbent franchisee's per-period rent, the relevant regulatory agency can always make sure that condition $(*)$ is satisfied. Finally, note also that the regulator would typically want to set the left-hand-side of $(*)$ as low as possible in order to minimize the rent captured by the incumbent franchisee.

The next rule further constrains the regulator's behavior. Recall that if either the incumbent franchisee or its rival make a higher bid for the license to operate the franchise, the regulator awards it with the license. It is possible however, that they bid exactly the same amount. In this case we assume that the regulator awards the license to the rival firm if the incumbent franchisee provided low quality service in the last period, but it lets the incumbent franchisee retain the license if the incumbent provided high quality service in the last period. In an environment where quality is non-verifiable and hence not directly contractible, this provides an easily justifiable way for the regulator to discipline the incumbent franchisee.

Regulator's Rule 2 (RR2, "Tie-Breaking Rule"). *If at (the end of) any period t the rival firm and the incumbent franchisee bid the same amount $b_t^I = b_t^R$ for the license, then the regulator awards the license to the incumbent if it provided high quality service in period t, and to the rival firm if the incumbent provided low quality service in period t.*

Together, RR1 and RR2 ensure that providing high quality service is an equilibrium of the game.

Proposition 1. *Suppose that firms have verifiable technological capabilities, and the regulator follows RR1-RR2. There exists a subgame perfect equilibrium in which the incumbent franchisee always provides high quality service (and is never replaced).*

The strategies that support this subgame perfect equilibrium are as follows: The incumbent franchisee provides high quality service in every period. Whenever it is challenged, it matches any bid that is equal or below the discounted sum of payoffs from providing high quality service taking the cost of bidding into account. If a higher bid is submitted, the incumbent declines to bid. Rivals' strategies are as follows. If at any period the incumbent

[22] If the efficiency loss from increasing the price is larger than the efficiency loss from raising taxes, rather than allowing the franchisee to charge a price above marginal cost the regulator should pay a subsidy to the franchisee that is financed by taxes.

franchisee provided low quality service, then the next rival firm bids an amount equal to the discounted sum of payoffs from providing high quality service taking the cost of bidding into account. Rival firms decline to bid otherwise. Along the equilibrium path, the incumbent franchisee always provides high quality service and is never replaced.

It is easy to verify that this is indeed a subgame perfect equilibrium. If the incumbent franchisee provides low quality service, then the next rival firm will bid for the license and win since it is favored by the regulator's tie-breaking rule. RR1 then implies that the maximum profit that the incumbent franchisee can achieve by providing low quality service for one period is lower than the sum of discounted profits if it continues to provide high quality service forever.

However, as the next two examples show, this is not the only equilibrium of the game. For simplicity, in both examples, it is assumed that all firms have the same technological capability a, and that the regulator sets the same franchise contract in every period. The statement "bid B" should be interpreted as "bid the highest integer multiple of the bid increment m that is smaller or equal to B." We denote the (stationary) per-period payoff of an incumbent franchisee that provides low quality by $\overline{\pi}$, and of an incumbent franchisee that provides high quality service by $\underline{\pi}$. By assumption, $\overline{\pi} > \underline{\pi} > 0$.

The next example illustrates the significance of focusing on subgame perfect as opposed to Nash equilibria.

Example 1 (Subgame perfect vs. Nash equilibrium). Consider the following profile of strategies: The strategy of every rival firm is to always challenge the incumbent franchisee by bidding $\frac{\overline{\pi}}{(1+\mu)(1+r)}$. The strategy of every incumbent franchisee is to provide low quality service after any history. When challenged, every incumbent franchisee bids the smallest possible amount that ensures its victory, but not more than $\frac{\overline{\pi}}{(1+\mu)(1+r)}$, after any bid that is strictly lower than $\frac{\overline{\pi}}{(1+\mu)(1+r)}$. It declines to bid otherwise. Note that this is a Nash equilibrium of the game. Since the incumbent franchisee is challenged regardless of its choice of quality, its best response is to provide low quality service. However, this equilibrium is not subgame perfect. If the incumbent franchisee provides high quality service (and matches any bid up to $\frac{\underline{\pi}}{(1+\mu)r}$ if challenged), the next rival would be better off not bidding against it since it will incur the cost of submitting a bid but because of the tie-breaking rule will lose.[23] But if the

[23] $\frac{\underline{\pi}}{(1+\mu)r}$ is the discounted sum of payoffs from continuing to provide high quality service forever, taking the cost of bidding into account.

next rival firm declines to bid, providing high quality service is better than providing low quality service and the equilibrium unravels.

The next example demonstrates the problem that may arise when rival firms' strategies depend on the incumbent franchisee's identity.

Example 2 (The importance of Anonymity). Consider the following profile of strategies: The incumbent franchisee at time 1, i_1, provides low quality service as long as it remains the incumbent. Whenever challenged, it matches any bid that is smaller than the discounted sum of payoffs from continuing to provide low quality service, unchallenged, taking the cost of bidding into account, i.e., it matches any bid that is smaller than $\frac{\overline{\pi}}{(1+\mu)r}$, and declines to bid otherwise. The strategy of a rival firm that appears in any period $t \geq 1$ is to decline to challenge the incumbent franchisee if it is i_1. And, when facing any other incumbent franchisee, to decline to bid if the incumbent franchisee provided high quality service, and to bid $\frac{\pi}{(1+\mu)r}$ if the incumbent franchisee provided low quality service. While it holds the license to operate the franchise, the rival firm always provides high quality service and matches any bid that is smaller or equal to $\frac{\pi}{(1+\mu)r}$. Along the equilibrium path, the first incumbent franchisee provides low quality service in every period and is never challenged. The equilibrium is sustained because future rival firms treat i_1 differently from any other incumbent franchisee. They "allow" the first incumbent franchisee to provide low quality service but "demand" high quality service from any other incumbent franchisee. Since the payoff to an incumbent franchisee that provides high quality service in every period is lower than the payoff to an incumbent franchisee that provides low quality service (and retains the franchise) forever, the first incumbent franchisee can never be defeated.

Example 2 demonstrates the significance of anonymity.[24] It is important to emphasize that while Example 2 violates anonymity in that the incumbent's "name" matters, it is straightforward to modify the example so that strategies do not depend on names, and yet a similar equilibrium exists. This can be done, for example, by "identifying" firms according to the duration of time they held the license. In period t, rival firms strategies will depend on whether the incumbent franchisee held the license for t or fewer periods. Thus, anonymity may be violated even if agents have no "proper" names. However, true anonymity, or at least

[24] Anonymity may be interpreted as "competitiveness" of the underlying economic environment. See the discussion in Osborne and Rubinstein (1990), and Rubinstein and Wolinsky (1990).

the kind of anonymity that guarantees that the "good" equilibrium described in Proposition 1 is the unique subgame perfect equilibrium, can be achieved if the following two additional plausible assumptions are satisfied.

The first assumption imposes a restriction on what rival firms consider to be relevant history.

Assumption 1 ("Rival firms care only about the performance of the incumbent franchisee"). *When bidding for the license, rival firms' decisions about how much to bid depend only on what has happened since the current incumbent franchisee began operating the franchise and do not depend on the incumbent's identity.*

That is, when facing two different incumbent franchisees, with the exact same history of actions, a rival firm will bid the same against both. Furthermore, rival firms are assumed to ignore everything that has happened before the current incumbent franchisee has started operating the franchise. The latter part of Assumption 1, namely the assumption that rival firms bids should not depend on the incumbent franchisee's identity, should be interpreted as an assumption about the competitiveness of the underlying environment. We view competition as implying that rival firms do not condition their bids on "irrelevant" aspects of the history of play such as the incumbent franchisee's identity. Otherwise, some incumbent franchisees may be free from the threat of a challenge which implies that competition is, in some sense, inhibited.

We also assume,

Assumption 2 ("Firms have bounded recall"). *Firms do not remember what happened more than k periods ago for some finite $k \geq 1$.*

This is a standard "bounded rationality" type assumption. Here, it excludes implausible strategies that, in effect, eliminate competition by giving special treatment to particular incumbent franchisees (e.g., as explained above, to the first incumbent franchisee by conditioning their bids on its tenure). Assumption 2 is weak in that the length of firms' recall, k, can be arbitrarily large.

The following proposition shows that once we impose Assumptions 1 and 2, the (good) equilibrium depicted in Proposition 1 above is the unique subgame perfect equilibrium. Uniqueness is obviously important because without it, we cannot conclude that franchise bidding cannot lead to undesirable outcomes.

Proposition 2. *Suppose that firms have identical and verifiable technological capabilities, and the regulator follows RR1-RR2. Then, the game described above has a (generically) unique subgame perfect equilibrium that satisfies Assumptions 1 and 2. In this equilibrium, the incumbent franchisee always provides high quality service and is never replaced.*[25]

The uniqueness of the equilibrium depicted in Proposition 1, even under Assumptions 1 and 2, is by no means obvious. For example, one may speculate that the incumbent franchisee can provide low quality service but the next rival firm may be wary of challenging it because the rival firm believes that if it becomes the incumbent franchisee itself, it would be challenged by future rival firms and have to pay to keep its license whereas the incumbent franchisee would not. As a consequence, the rival firm would be willing to pay less for the license and since bidding is costly, would not attempt to bid for the license. The proof of Proposition 2 shows that such wariness on the part of rival firms is incompatible with the logic of subgame perfect equilibrium.

Because firms have bounded recall, the rival firm that appears in period t, call it j, knows that if it survives k periods as the incumbent franchisee (i.e., if it is the incumbent franchisee at $t+k+1$), it will be treated thereafter exactly as the present incumbent franchisee, call it i, would. Therefore, k periods into the future (i.e., in period $t+k$), j would be willing to pay the same amount the incumbent franchisee i would for the right to operate the franchise in period $t+k+1$. Assumption 1 implies that the rival firm that will appear in period $t+k$ (challenging the incumbent franchisee of period $t+k$ for the license in period $t+k+1$ onwards) will only be judged according to its own performance. It will therefore be indifferent between challenging firm j or the incumbent franchisee i and will therefore treat both identically. Realizing this, firm j would also realize that it faces the exact same future as the incumbent franchisee i, k rather than $k+1$ periods into the future. The same argument can be repeated to show that firm j would be treated exactly as the incumbent franchisee also $k-1$ periods into the future. Repeating this argument $k-2$ more times implies that the rival firm j and the incumbent franchisee can expect to be treated in the same way by all future rival firms. But, in this case, the regulator's tie-breaking rule implies that an incumbent franchisee who chooses to provide low quality service gives up its advantage as the incumbent and is surely going to be defeated by the next rival firm. On the other hand,

[25] We use the term "generically" in the following sense: the franchisee's payoff $\pi_t(\cdot,\cdot)$ is generically not equal to some integer multiple of the bid increment m.

if it chooses to provide high quality service, it can count on the regulator's "support" and will win every future contest by matching rival firms' bids. All rival firms realize this and therefore, since bidding is costly, decline to bid against incumbent franchisees that provide high quality service.

At a more general level, the intuition for Proposition 2 is that competition works. Taken together, Assumptions 1 and 2 imply that competition for the franchise contract is not inhibited by "special treatment" of specific incumbent franchisees which shields them from competition. Every incumbent franchisee is subject to the threat of being successfully challenged if it ever provides low quality service. Because of this threat, every incumbent provides high quality service in every period. Thus, if the market for the franchise contract is competitive enough, Assumptions 1 and 2 are satisfied, and contestable licensing leads to the efficient outcome.

Finally, Proposition 2 may be interpreted as a refinement, namely, as an argument in favor of focusing attention on one specific attractive equilibrium. The infinite game we described has many equilibria, but only one equilibrium that relies on strategies that satisfy the "attractive properties" described in Assumptions 1 and 2 above.

3.2. The Case of Observable but not Verifiable Technology

In this subsection we extend the analysis presented in the previous subsection to include the case where technological capabilities may differ across firms, be observable by the regulator, but not verifiable in court. Thus, the regulator may not be able to dismiss the incumbent franchisee upon its failure to invest in maintaining its technological capability.

Nevertheless, it can be verified that Proposition 1 (which established the existence of a "good" equilibrium) still holds, and once an additional monotonicity assumption is made, uniqueness follows too.

Assumption 3 ("Rival firms' bids are monotone in the incumbent franchisee's technological capability"). *For every rival firm j, if j bids for the right to operate the franchise against an incumbent franchisee with technological capability a^*, then after an identical history, j also bids against an incumbent franchisee with technological capability $a < a^*$.*

Assumption 3 can be motivated by considering the regulator's role in affecting the technological capability of rival firms and the incentives that firms have to reveal their true tech-

nological capabilities. Suppose that rival firms' strategies are not monotone in the incumbent franchisee's technological capabilities. Future rival firms challenge technologically advanced franchisees but decline to challenge technologically inferior franchisees. Suppose further that as a consequence of this behavior, technologically superior firms decline to challenge the current incumbent franchisee. The regulator can overcome this difficulty by soliciting a bid from a technologically less advanced firm, or, a technologically superior firm can pretend to have a lower technological capability than it really has. For the sake of simplicity, we rely on Assumption 3 instead of considering a more general model where the regulator can affect rival firms' technological capabilities by soliciting bids from certain firms and not others, and franchisees can pretend to have lower technological capabilities (but not higher ones). The next example demonstrates that unless such a more general model is considered, Assumption 3 is necessary for our results.

Example 3 (The importance of the monotonicity). The example is similar to Example 2. It considers a case where the incumbent franchisee's technological capability uniquely identifies it, thereby violating anonymity, in spite of the fact that firms cannot be identified by their proper names. Suppose that technological progress stops after the first period. Firms then may have two technological capabilities, high $a_H = a_2$ and low $a_L = a_1$. Suppose further that except for the first incumbent franchisee who did not invest in technological improvement and has a low technological capability, all other firms have high technological capabilities. Since firms' strategies may depend on the incumbent franchisee's technological capability, the equilibrium profile of strategies described in Example 2 is a subgame perfect equilibrium here as well. Rival firm "allow" the first incumbent franchisee to provide low quality service, but "demand" high quality service from all other firms. Thus, although it is technologically inferior, the first incumbent franchisee earns higher profits than other firms and is therefore never challenged.

We have the following Proposition,

Proposition 3. *Suppose that the regulator follows RR1 and RR2. Then, the game described above has a generically unique subgame perfect equilibrium that satisfies Assumptions 1, 2, and 3. In this equilibrium, the incumbent franchisee always provides high quality service, and in every period invests in maintaining its technological capability. It is never challenged.*[26]

[26] The notion of genericity is identical to the one used in the statement of Proposition 2 (i.e., the franchisee's

The strategies that support this equilibrium are similar to those that support the equilibrium described in Proposition 1. The proofs, however, are somewhat different. Lemma 3 in the Appendix shows that Assumption 3 implies that technologically superior firms always defeat technologically inferior firms, independently of the quality the technologically inferior firm has provided. Thus, whenever the incumbent franchisee neglects to invest in improving its technological capability, it is challenged by a rival firm that possesses a better technology and so defeats the incumbent. Whereas in the proofs of Propositions 1 and 2, the incumbent franchisee invested in improving its technological capability because the regulator would have dismissed it had it done otherwise, when technological capability is not verifiable, the incumbent franchisee invests because otherwise, it will be outbid by a technologically superior rival firm and lose the license.

3.3. The Case of Non-Observable Technological Capability

When technology is not observable, let alone verifiable, then the terms of the franchise contract cannot be made to directly depend upon it. In this case, the franchisee may not invest in reducing its cost unless it is given the appropriate incentive to do so. The regulator, however, may design the terms of the franchise contract so that the incumbent franchisee keeps a large fraction of its cost savings, thereby providing the franchisee with "high-powered" incentives to reduce cost. The logic of our previous results with respect to the provision of quality still applies, so that in contrast with the rest of the literature where incentives to provide high quality conflict with incentives to reduce cost (see, e.g., Laffont and Tirole (1994) and the references therein), here such a conflict does not arise.

4. Discussion

4.1. Robustness with respect to Regulator's Malleability

Under the current regulatory regime, it is difficult if not impossible for a regulatory agency to commit to an action that is against the interest of regulated industry and is based on non-verifiable information. Even if such commitment is possible, the associated legal costs that arise when the regulator's decision is challenged in court are likely to be prohibitive. Consequently, it is very difficult for regulatory agencies to pressure regulated industries into

payoff $\pi_t(\cdot,\cdot)$ is generically not equal to some integer multiple of the bid increment m).

providing high non-contractible quality. The franchise bidding scheme described in this paper increases the regulator's discretion so that such commitment is made possible. This additional discretionary power is minimal – the regulator should still be able to justify its decisions in court, but should be held to weaker standards of proof. The regulator is called to exercise judgement only in the unlikely event where two firms have submitted identical bids. The rarity of such situations promises that they will focus the public's attention on the regulator's decision which will further constrain it from behaving opportunistically. Furthermore, various consumer groups may act as watchdogs and, upon observation of low quality service, apply pressure on the regulator to make it commonly known that it will henceforth resolve ties in favor of rival firms.[27] To a benevolent regulator, this added discretion facilitates an easily justifiable way of dismissing incumbent franchisees who provided low quality service. After all, even if it is not verifiable, the fact that the incumbent franchisee provided low quality service is observable, and a rival firm who is willing to operate the franchise under the same conditions and is willing to pay for this right as much as the incumbent is, is readily available.

Under so-called "direct" or "command and control" regulation, increasing the regulator's discretion so that it can dismiss the franchisee at will is not likely to be as robust against regulatory capture. Suppose for example that as formulated, the details of the franchise contract promote efficiency (i.e., RR1 is satisfied) but the incumbent regulator may be subject to regulatory capture. It may fail to dismiss the incumbent franchisee upon observation of low quality service with a certain, commonly known, probability $0 < p < 1$.[28] Under direct regulation, a high enough p implies that incumbent franchisees will provide low quality service. However, under the franchise bidding scheme we propose, if consumer groups are willing to cover the bidding costs of a rival firm, a rival firm who notices that low quality service is provided by the incumbent franchisee may still challenge the incumbent for the

[27] The evidence presented in Besley and Coate (1999) that showed that electricity prices are on average lower in states where regulators stand for public election than in states where they are appointed suggests that the public may well act as an effective "watchdog" against regulatory capture.

[28] This distinction between the efficiency of the rules on the one hand and the effectiveness of rule enforcement on the other is standard in the literature. Perhaps because verifying a document (the rules), may be easier than verifying the state of the world (enforcement), the literature typically assumes that the efficiency of rules may be easier to ensure than effective enforcement. See Laffont and Tirole (1994, ch. 15) and the references therein.

right to operate the license.[29] Even if a tie occurs and the regulator resolves the tie in favor of the incumbent franchisee, the incumbent franchisee still has to pay, whereas under direct regulation it would not. Furthermore, anticipating this, the incumbent franchisee may provide high quality service in order to prevent such challenges from occurring in the first place.

The previous argument in favor of contestable licensing can be easily "formalized" and incorporated into the model. The next argument, while perhaps not any less important or valid, is more difficult to explicitly formalize without introducing significant changes to the model. Due to free-rider problems, it is difficult for consumers, as a group, to supervise regulators that abuse their discretionary power. The advantage of contestable licensing compared to direct regulation is that under the former, the rival firm can help organize consumer resistance so as to mitigate the free-rider problem mentioned above. In addition, the presence of a clear alternative may make resistance more effective relative to the case where no such alternative exists as is the case under direct regulation.

4.2. Robustness with respect to Uncertainty

The result that in the equilibrium we describe in Proposition 3, the same incumbent franchisee retains the license forever hinges on the fact that we model technological progress as a deterministic process. The basic model described in Section 2 can be expanded to incorporate uncertainty about the underlying environment, and hence also about the future terms of the franchise contract, about the technological capability of future rivals, and about the return to investment in improving the technological capability of the incumbent franchisee. We would need to modify RR1, but our main results would remain qualitatively unchanged. The incumbent franchisee would retain the license for a long period of time rather than forever, and providing low quality service would imply that the incumbent franchisee is very likely, as opposed to certain, to be challenged and replaced. To support this new equilibrium, RR1 would have to be modified to incorporate the incumbent franchisee's expectations about future changes in the underlying environment and about the terms of the franchise contract

[29] Moreover, if the cost of bidding is small relative to the bidding increment, so that the net gain from obtaining the license taking into account the price paid and the probability of winning is larger than the cost of bidding, rival firms will be willing to bid against the incumbent franchisee even if their costs are not covered by consumer groups.

in such a way that the following two conditions are satisfied: (1) as long as the incumbent franchisee continues to invest in technological improvement, the likelihood that a technologically superior rival firm appears remains small; and (2) the likelihood that at any point in time, the rival firm has a technological capability that is equal to that of the incumbent franchisee's is high. The first condition, which may be interpreted as implying the difficulty of achieving exceptional technological advancements, is required to ensure that the incumbent franchisee indeed retains the license for a long enough period of time. The second condition, which may be interpreted as implying considerable technological spillovers, is required in order to discipline the incumbent franchisee. Unless it is satisfied, incumbent franchisees may be tempted to try and capitalize on their technological advantage by providing low quality service.

4.3. Sunk Costs, the Transferability of Investment, and Asset Specificity

Williamson's (1976) main criticism of the "Chicago School approach" to franchise bidding concerns what he claimed was its facile dismissal of the related issues of sunk costs, the incentives to invest, the transferability of investment and asset specificity. The basic problem is as follows. Suppose that the incumbent franchisee has to incur a large irreversible cost in order to operate the franchise. This gives the incumbent franchisee a clear advantage over its rivals since in the bidding stage, potential rival firms have to consider their future per-period profits as well as the required irreversible costs, whereas the incumbent franchisee, for whom these costs are sunk, only has to consider its future per-period profits. This asymmetry between the incumbent and its rival may give rise to several types of inefficiencies: First, the presence of sunk costs biases the bidding in favor of the incumbent franchisee who may outbid its rivals in spite of being less productively efficient and expecting lower profits. Second, incumbent franchisees may under-invest in capital equipment for fear they will not be able to recapture their investment when they are replaced. And third, the sunk costs may have to be incurred again and again as the incumbent franchisee is replaced, which is socially wasteful.

Regarding the first problem, it is possible to restore the bidding parity between the incumbent franchisee and rival firms by compensating firms for their capital investments. A way to do this is to require the successful rival to pay the defeated incumbent an amount equal to the estimated value of the capital stock involved. Alternatively, in many cases

the state is or can be made the owner of all capital equipment.[30] It is also important to emphasize that even if bidding parity is violated, then as long as this violation is not so large as to eliminate all effective competition and destroy the incumbent franchisee's incentives to provide high quality service, a sufficiently technologically superior rival may still outbid the incumbent franchisee.

Demsetz (1968) and Posner (1972) anticipated the second point above by describing various ways according to which incumbent franchisees can be compensated for their capital investments, and the third point by remarking that incumbent franchisee's capital investments can be transferred from one incumbent franchisee to the next to minimize social inefficiency. However, Williamson (1976) pointed to the difficulties associated with these schemes especially when capital investments are highly specific.[31] He concluded that in those industries where assets are generally less specific such as local service airlines, postal delivery, and trucking, franchise bidding may be a satisfactory solution, but in other industries such as utility services (gas, water, electricity, telephone), direct regulation is likely to perform at least as well as franchise bidding.

An insight that can be gained from our approach is that along the equilibrium path, the incumbent franchisee may (efficiently) retain the license for long periods of time. Thus, the last two problems above need not imply great losses of social welfare.

Finally, in some cases, the problems caused by sunk costs or asset specificity may be so overwhelming that our approach may not be applicable. However, we believe that in many cases, contestable licensing will generate efficient outcomes as long as the basic argument made here is appropriately modified to fit the particular circumstances of every case.

5. Conclusion

The analysis presented here argues for the potential benefits of contestable licensing in natural monopoly environments where quality is observable but not verifiable. We should emphasize that our purpose is not to defend "markets" against "regulation," but rather to

[30] See Schmalensee (1979) and the references therein for descriptions of cases where this was done in practice.

[31] Williamson (1976) also elaborated on the difficulties of correctly measuring capital invesments. These concerns pose less of a problem if firms are approximately risk neutral and the regulator observes an approximately unbiased signal about the franchisee's capital investment.

consider a possible reform of regulatory policy in a direction that calls for more competition together with a little more discretion on part of the regulator. We hope that reframing the argument between the "Chicago approach" and Williamson (1976) in the context of the agenda of the incomplete-contract approach to public decision making (Laffont and Tirole, 1994, p. 594) helps clarify some of the basic ideas and suggests some directions for further research.

Appendix

Proof of Proposition 1. Recall that the statement "bid b" should be interpreted as "bid the highest integer multiple of m smaller or equal to b." Consider the following profile of strategies: The incumbent franchisee provides high quality service in every period. Whenever challenged, an incumbent franchisee that has always provided high quality service matches any bid that is equal or below the discounted sum of payoffs from providing high quality service taking the cost of bidding and the cost of maintaining technological capability into account, or

$$\frac{1}{1+\mu}\sum_{\tau=1}^{\infty}\left(\frac{1}{1+r}\right)^{\tau}\left[\pi_{t+\tau}\left(a_{t+\tau},q_H\right)-c_\tau\right].$$

In case a higher bid is submitted, the incumbent franchisee declines to bid. An incumbent franchisee that has provided low quality service in the last period responds to any challenge that is equal or below the highest integer multiple of m equal or below

$$\frac{1}{1+\mu}\sum_{\tau=1}^{\infty}\left(\frac{1}{1+r}\right)^{\tau}\left[\pi_{t+\tau}\left(a_{t+\tau},q_H\right)-c_\tau\right]-m$$

by bidding the smallest integer multiple of m above it, and declines to respond to higher bids. Rival firms' strategies are as follows. If the incumbent franchisee provided low quality service in any period t, then the rival firm that appears at the end of period t bids an amount that is equal to the discounted sum of payoffs from providing high quality service taking the cost of bidding as well as maintaining technological capability into account. Rival firms decline to bid otherwise. Note that along the equilibrium path, incumbent franchisees always provide high quality service and are never challenged.

It is easy to verify that this is indeed a subgame perfect equilibrium. The tie-breaking rule employed by the regulator implies that the incumbent franchisee is immediately replaced if it ever provides low quality service. RR1 implies that the incumbent franchisee is sufficiently forward looking to prefer the discounted sum of payoffs associated with continuing to provide high quality service to the payoff it could get by deviating and providing low quality service. It is straightforward to verify that rival firms' strategies are optimal as well. ■

Proof of Proposition 2. The proof follows from the next two lemmas.

Lemma 1. *Generically, in every subgame perfect equilibrium, an incumbent franchisee is successfully challenged and replaced at the end of any period in which it provided low quality service.*

Proof. Fix a subgame perfect equilibrium (SPE). Suppose that at some period t, the incumbent franchisee, denoted i, provided low quality service. Denote the rival firm that appears at the end of the period by j. Denote the SPE discounted sum of payoffs the incumbent franchisee expects to get from period $t+1$ onwards if it succeeds in deterring or defeating the challenger in period t by π^i_{t+1}. Similarly, let π^j_{t+1} denote the SPE discounted sum of payoffs that the rival firm in period t expects to get from period $t+1$ onwards if it succeeds in winning the license. Note that since the incumbent franchisee in period $t+1$ can always provide low quality service in period $t+1$ and decline to respond to challenges thereafter, both $\pi^i_{t+1}, \pi^j_{t+1} > 0$.

We show that $\pi^j_{t+1} \geq \pi^i_{t+1}$. Note that in this case, since the regulator's tie-breaking rule favors the rival firm j, this implies that j can defeat the incumbent franchisee by bidding no more than the highest integer multiple of m smaller or equal to $\frac{1}{1+\mu}\pi^i_{t+1}$ and generically obtain a positive payoff. Therefore, if $\pi^j_{t+1} \geq \pi^i_{t+1}$, then j will successfully challenge and replace the incumbent franchisee i in the SPE.

We show that there is a strategy for j under which $\pi^j_{t+1} \geq \pi^i_{t+1}$. In a SPE, since bidding is costly, if a bid is submitted, then it is successful. We can therefore distinguish between the following two cases: (1) There exists some period $T \geq t$ where along the SPE path, i is outbidden and loses the franchise, and (2) i is never outbidden on the SPE path after and including period t.

Consider case (1) first. Since if $T = t$, then along the SPE path j outbids i at t, we may assume that $T > t$. Now, j knows that if it retains the license up to period $T-1$, then starting from period T onwards, it can expect a larger or equal future discounted sum of payoffs than i because it can provide the same quality service as i does in period T and it may retain the license after T as well. Therefore, if challenged at the end of period $T-1$, j would be willing to bid at least as much as i would in order to retain the license. By Assumption 1, the rival firm that appears in period $T-1$ expects a future discounted payoff that depends only on how it itself performs while it holds the franchise. In particular, it is indifferent between bidding against i or j. Consequently, the rival firm that appears in period $T-1$ will (successfully) outbid j only if it will also successfully outbid i. Therefore, it must be the case that $\pi^j_{T-1} \geq \pi^i_{T-1}$. Repeating the same argument for period $T-2$ implies that $\pi^j_{T-2} \geq \pi^i_{T-2}$. Repeating the same argument $T-t-3$ more times, implies that it must also be the case that $\pi^j_{t+1} \geq \pi^i_{t+1}$.

Consider now case (2). By assumption, i is not outbidden along the SPE path. In particular, on the SPE path, i holds the franchise in period $t+k+1$. Suppose now that j outbids i in period t and then adopts the same strategy that i uses from time $t+1$ onwards. If j survives unchallenged to period $t+k+1$, then since it adopted i's strategy, the players' bounded recall implies that j will be treated thereafter no worse than i would, and thus $\pi^j_{t+k+1} = \pi^i_{t+k+1}$. The backwards induction argument presented in case (1) above can be then re-applied to imply that $\pi^j_{t+1} = \pi^i_{t+1}$. Therefore, to complete the proof of the lemma, we must show that j will indeed not be challenged between periods $t+1$ and $t+k$. This too is shown by backwards induction. Consider period $t+k$, and suppose that j has not been challenged between periods $t+1$ and $t+k-1$. If j defeats the rival firm at $t+k$, then, because of the players' bounded recall, it can expect to be treated no worse than i would thereafter, and thus $\pi^j_{t+k+1} = \pi^i_{t+k+1}$. j would therefore be willing to bid as much as i would in order to defeat the rival firm at $t+k$. By Assumption 1, the rival firm that appears in period $t+k$ expects a future discounted payoff that depends only on how it itself performs while operating the franchise. In particular, it is indifferent between bidding against i or j. By assumption, on the SPE path, the rival firm at $t+k$ refrained from bidding against i, therefore, it must also refrain from bidding against j. But this implies that j and i expect the same future discounted payoff starting from period $t+k$, and thus $\pi^j_{t+k} = \pi^i_{t+k}$. Repeating the same argument $k-1$ more times implies that j would not be challenged anytime between periods $t+1$ and $t+k$.[32] ■

Lemma 2. *Generically, in every subgame perfect equilibrium, an incumbent franchisee is not challenged (or replaced) at the end of a period in which it provided high quality service.*

Proof. The proof is similar to the proof of the previous lemma. Fix a subgame perfect equilibrium (SPE) and a time t. Recall the definitions of π^i_{t+1} and π^j_{t+1} from the proof of the previous lemma. Suppose that contrary to what is claimed, the incumbent franchisee i at t is successfully challenged and replaced by a rival firm j at the end of a period where it provided high quality service. By assumption, the incumbent franchisee at t is favored by

[32] The argument bears a superficial resemblance to Jéhiel (1995) and Jéhiel and Moldovanu (1995). However, our argument is different. Among other things, the assumption of bounded recall, by itself, is not sufficient for our result, and, while in Jéhiel (1995) and Jéhiel and Moldovanu (1995) the players' forecasts or behavior strategies, respectively, are history-independent, this is obviously not the case here.

the regulator's tie-breaking rule. Therefore the fact that i is successfully challenged implies that it must be the case that $\pi_{t+1}^{j} > \pi_{t+1}^{i}$. We show that this cannot be and obtain a contradiction. The proof is identical to the one given in the previous lemma with the roles of i and j reversed. ■

Proof of Proposition 3. The proof is similar to the proof of Propositions 1 and 2. We first describe the subgame perfect equilibrium and then prove that it is generically unique. Recall that the statement "bid b" should be interpreted as "bid the highest integer multiple of m smaller or equal to b." Consider the following profile of strategies: The incumbent franchisee provides high quality service in every period, and in every period, invests in maintaining its technological competitiveness. Whenever challenged, an incumbent franchisee that has always provided high quality service matches any bid that is equal or below the discounted sum of payoffs from providing high quality service taking the cost of bidding as well as the cost of maintaining technological competitiveness into account, or

$$\frac{1}{1+\mu}\sum_{\tau=1}^{\infty}\left(\frac{1}{1+r}\right)^{\tau}\left[\pi_{t+\tau}\left(a_{t+\tau},q_H\right)-c_{t+\tau}\right].$$

In case a higher bid is submitted, the incumbent franchisee declines to bid. An incumbent franchisee that has provided low quality service in the last period responds to any challenge that is equal or below the highest integer multiple of m equal or below

$$\frac{1}{1+\mu}\sum_{\tau=1}^{\infty}\left(\frac{1}{1+r}\right)^{\tau}\left[\pi_{t+\tau}\left(a_{t+\tau},q_H\right)-c_{t+\tau}\right]-m$$

by bidding the smallest integer multiple of m above it, and declines to respond to higher bids. Rival firms' strategies are as follows. Rivals that have the same technological capability as the incumbent franchisee bid an amount that is equal to the discounted sum of payoffs from providing high quality service taking the cost of bidding as well as the cost of maintaining technological competitiveness into account if the incumbent provided low quality service, and decline to bid otherwise. Rivals with superior technologies bid m above that (and win the license in equilibrium). Along the equilibrium path, incumbent franchisees always provide high quality service and invest in improving their technological capability. They are never replaced.

It is easy to verify that this is indeed a subgame perfect equilibrium. If the incumbent franchisee ever provides low quality service, then a rival firm, that is at least as equally

technologically advanced, bids for the license and wins since it is favored by the regulator's tie-breaking rule. If the incumbent franchisee ever fails to invest in improving its technological capability, then a technologically superior rival firm appears, outbids the incumbent and wins the license. RR1 implies that the incumbent franchisee is sufficiently forward looking to prefer the discounted sum of payoff associated with continuing to provide high quality service and investing in improving its technological capability, to the payoff it could get by deviating and providing low quality service, or failing to invest in improving its technological capability.

The proof of uniqueness follows from the next lemma.

Lemma 3. *In every subgame perfect equilibrium, a firm that has superior technology always outbids a firm with inferior technology.*

Proof. Fix a subgame perfect equilibrium (SPE). Suppose that at some period t, an incumbent franchisee i with technology a faces a rival firm j with superior technology. As in the proof of Lemma 1, denote the SPE discounted payoff the incumbent franchisee i expects to get from period $t+1$ onwards if it succeeds in deterring or outbidding the rival firm j in period t by π^i_{t+1}. Similarly, let π^j_{t+1} denote the SPE discounted payoff that the challenger firm j expects to get from period $t+1$ onwards if it succeeds in outbidding the incumbent franchisee i and obtaining the license to operate the franchise. As before, note that since the incumbent franchisee in period $t+1$ can provide low quality service in period $t+1$ and decline to respond to challenges, both $\pi^i_{t+1}, \pi^j_{t+1} > 0$. We show that $\pi^j_{t+1} > \pi^i_{t+1}$. Note that this implies that j can defeat i by bidding no more than the highest integer multiple of m smaller or equal to $\frac{1}{1+\mu}\pi^i_{t+1} + m$, and still generically obtain a positive payoff. Therefore, if $\pi^j_{t+1} > \pi^i_{t+1}$, then j will successfully challenge and replace the incumbent franchisee i.

We show that there is a strategy for the rival firm j at t under which $\pi^j_{t+1} > \pi^i_{t+1}$. The proof is almost identical to the one given in Lemma 1 and is therefore not reproduced. The only differences between this proof and the one given before are that (1) here, because of j's technological superiority, we obtain strict as opposed to weak inequalities, and (2) here, we need to rely on Assumption 3 (monotonicity) instead of anonymity to guarantee that after a sufficiently long history, i and j will be treated equally by all future rival firms.

A similar argument applies when the challenger firm j is technologically inferior to the incumbent i. However, in this case, because of the cost of bidding, along the equilibrium

path j would not bid for the license. This completes the proof of the lemma. ■

To complete the proof of the proposition, note that Lemmas 1 and 2 above still apply here with the qualification that only incumbents and rivals that have the same technological capability are considered. ■

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